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Applicants:	John Erik Aasted SORENSEN	Conf. No.:	1786
Title:	A METHOD OF AND A SYSTEM FOR SURVEILLANCE OF AN ENVIRONMENT UTILISING ELECTROMAGNETIC WAVES		

PRIORITY LETTER

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Dear Sirs:

Pursuant to the provisions of 35 U.S.C. 119, enclosed is a certified copy of the following priority document.

Application No.	**Date Filed**	**Country**
PA 2002 00997	June 26, 2002	DENMARK

In support of Applicant's priority claim, please enter this document into the file.

Respectfully submitted,

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Title: A method of and a system for surveillance of an environment utilising electromagnetic waves.

IPC: -

This is to certify that the attached documents are exact copies of the above mentioned patent application as originally filed.

Patent- og Varemærkestyrelsen
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1. September 2003

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PVS

A METHOD OF AND A SYSTEM FOR SURVEILLANCE OF AN ENVIRONMENT UTILISING ELECTROMAGNETIC WAVES.

BACKGROUND OF THE INVENTION AND INTRODUCTION TO THE INVENTION

The present invention relates to a method of and system for surveillance of a physical environment using electromagnetic waves. The physical environment considered is typically buildings, open places and the like, and the environment is typically composed of electrically conducting and non-conducting solid construction materials, e.g. iron reinforced concrete and wood, and biological construction materials which constitutes e.g. human beings, animals, trees. Furthermore, the physical environment may contain materials in a liquid state e.g. water. A general concept of preferred embodiments of the present invention relates to surveillance of a physical environment by measuring changes in the propagation properties of electromagnetic waves through the environment.

SUMMARY OF THE INVENTION

In one aspect, the present invention relates to a surveillance system. The system comprises preferably at least one transmitter adapted to transmit a signal in form of *electromagnetic radiation and* at least *one receiver adapted to receive said signal in form* of electromagnetic radiation, said system being further adapted to

- transmit, by use of one of the at least one transmitters, a first signal and a second signal, the second signal is succeeding the first signal,
- receive said first and second signals, by use of one of the at least one receivers, and
- detect a physical change, if present, in the vicinity of the transmitter transmitting and the receiver receiving and occurring between initiating of transmittal of the first signal and termination of receiving the second signal by detecting a change, provided by said physical change, in signal strength between the first and the second signal.

In a second aspect, the present invention relates to a surveillance method. The said method utilises preferably at least one transmitter adapted to transmit a signal in form of electromagnetic radiation and at least one receiver adapted to receive said signal in form of electromagnetic radiation, and the method comprises preferably the steps of

- transmitting, by one of the at least one transmitters, a first signal and a second signal, the second signal is succeeding the first signal,
- receiving said first and second signals, by one of the at least one receivers, and

- detecting a physical change, if present, in the vicinity of the transmitter transmitting and the receiver receiving and occurring between initiating of receiving of the first signal and termination of transmittal of the second signal by detecting a change, provided by said physical change, in signal strength between the first and the second signal.

Thus, surveillance systems and methods according preferred embodiments of the present invention are preferably based on an estimation of the transmission properties between the APs, and the detection of the influence, a change in the physical environment around and between the APs might imply on these properties. A change might, f.inst. be the movement of a person or a chair. A detected change is then denoted an event.

BREIF DESCRIPTION OF THE DRAWING

The present invention, and in particular preferred embodiments thereof, will now be presented in connection with the accompanying drawing, in which

Fig. 1 shows an environment according to preferred embodiment of the present invention. Fig. 1 shows a room with 4 walls, a floor and a ceiling. Inside the room there is a table, a computer and a chair. Some of the major construction elements of the chair are assumed to be metallic. At the midpoint between the two upper left corners of the room, is positioned a Wireless Local Area Network (WLAN) Access Point (AP). Furthermore an AP is positioned at the midpoint of the nearest left wall, and in the rightmost corner, a short distance above the floor. The WLAN is designed such that the APs can communicate, and furthermore the computer can communicate with one or more of the APs.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE PRESENT INVENTION

An overall concept of preferred embodiments according to the present invention is indicated in Fig. 1 which shows a room being configured with a wireless local area network (WLAN) having transceivers, i.e. a device comprising a transmitter (TX) for transmitting and receivers (RX) for receiving electromagnetic radiation. The transceivers (1) constitutes access points (AP) in the WLAN.

Within the room a computer (2) is present, which computer comprising a transceiver enabling data communication with a server via the transceivers (1). Furthermore, three transceivers (1) and thereby three access points (AP) are present in the room as shown in fig. 1.

It is noted that the WLAN is preferably of the known and ordinary type, but it is contemplated that transmitters, receivers and/or transceivers dedicated surveillance purposes may be applied in connection with the present invention.

When the WLAN is used for surveillance in accordance with the present invention, the WLAN is operated in two different modes: mode 1 and mode 2.

In mode 1, a set of packets is transmitted from a transceiver (1). The number of packets in the set being preferably transmitted during a time window having a predetermined length, T_1. Each packet contains, preferably, information on the signal strength by which each packet is transmitted. Upon receipt of the packets by the transceiver (1), the strength of each packet is detected, recorded and stored together with in the information on the signal strength by which each packet was transmitted, thereby establishing a mode 1 vector comprising, for each package in the set, the transmitted and the received signal strengths.

Following this mode 1, which may be characterised as determining a basis for comparison, mode 2 is carried out. Basically the same steps as performed in mode 1 are carried out, i.e. transmitting a set of packets and receiving, detecting and recording the strengths thereof, whereby a mode 2 vector is established comprising, for each package in the set, the transmitted strength and the received strength.

It is noted, that in a WLAN operated to continuously transmit packets, the sets considered above may be defined by only recording information on the strengths in the given time windows.

The information contained in the mode 1 and mode 2 vectors is now analysed to identify any significant difference between them. If a significant difference is identified, this is an indication of that an event influencing the transmission of electromagnetic radiation occurred after mode 1 was initiated and mode 2 was completed.

Another advantageous effect of the present invention, may be obtained by tuning the system to identify specific events. This is done by analysing the effect a known event has on the mode 2 vector and storing this information for later on the fly comparison for identification.

It should be noted, that even though it is preferred to use the same number of packets and time window in mode 1 and mode 2, it is contemplated that this is not a pre-requisite

for the invention. One could easily consider to embody the system in a manner where mode 1 contains many more packets than mode 2. Furthermore, one could easily consider to embody the system in a manner where the mode 1 vector is obtained in advance and under predetermined known conditions whereby any difference to such known conditions would be reflected in the mode 2 vector.

Furthermore, the invention may also be embodied as a system utilising detection of changes in a carrier wave like signal, that is transmission of a continuous wave by one of the transmitters. In such a system, the receiver detects, in mode 1, the signal in a first time windows and performs for instance an integration over time of the received signal. In mode 2, the same procedure is applied and the signal is integrated. The two integrated signals are then compared to each other and if a difference is found an indication of a change in the VOI is detected.

The transceivers (1) are connected via wires to a server. The purpose of the server is to control the transceivers (1) and to perform the data-processing. The data-processing comprising outputting to the transceivers (1) information on which signal to be transmitted and perform the comparison of the signals received during mode 1 and mode 2. It should, however, by noted that the data-processing may be made an integral part of the functioning of the transceivers (1).

Considering the above, the invention may in general be seen to be represented by the following items:

A 3D physical environment of interest which in the following is denoted Volume of Interest (VOI). The physical material in VOI is represented by the spatial position dependence of the constitutive relations of the Maxwell equations, where the physical material is characterized by the material parameters permittivity ε, permeability μ and conductivity σ. One such example may be: The VOI can be the interior of a house, including the nearest outdoor environment of the house.

An event within the VOI, is characterised by a change in one or more of the physical material parameters, within a time window. This means that $\varepsilon=\varepsilon$(spatial position, time), $\mu=\mu$(spatial position, time) and $\sigma=\sigma$(spatial position, time). One such example may be: A person moves from one room in a house to another.

The position of an event is the spatial position of the changed material parameters within the VOI. One such example may be: The spatial position of a person within a house.

Surveillance system components denoted GE, TX, RX and DT where:

- GE is a generator which delivers data sequences, to be transmitted by the electromagnetic wave transmitter TX.
- TX is an electromagnetic wave transmitter, working at a carrier frequency f. The transmitter is equipped with an antenna.
- RX is an electromagnetic receiver, receiving at the carrier frequency f. The receiver is equipped with an antenna.
- DT is a data sequence detector connected with RX. DT works in two modes. In Mode 1, a model estimated from the received signal strength at the carrier frequency of the propagation path from TX to RX, is estimated. In Mode 2 it is tested, if the current signal strengths received through the propagation path deviate from the model estimated in Mode 1. The two DT working modes, represent several different ways of estimating a reference model for event detection, and for detecting an actual event. These include non-recursive and recursive methods, and methods based on prediction.

The combination of GE and DT can work in four function cases, denoted GE_DT_1 to GE_DT_4. The cases are determined by the capabilities of the GE, having completely control of the data sequence (DS) transmitted or not; and the capability of DT to carry out feed-back to GE, dependent of the received DS. This leads to the following:

GE_DT_1: GE does not have completely control of the DS. DT does not have feed-back capability to GE, dependent of the received DS.

GE_DT_2: GE does have completely control of the DS. DT does not have feed-back capability to GE, dependent of the received DS.

GE_DT_3: GE does not have completely control of the DS. DT does have feed-back capability to GE, dependent of the received DS.

GE_DT_4: GE does have completely control of the DS. DT does have feed-back capability to GE, dependent of the received DS.

Thus, a surveillance system may preferably comprise a volume of interest (VOI), in which a transmitter (TX) and a receiver (RX) are mounted in known spatial positions. One example of the operation of the surveillance system for event detection is as follows: In Mode 1, the detector DT estimates, through the time period T_{start} to $T_{stop} = T_{start} + T_1$, the received signal statistics of the GE data sequence transmitted from TX to RX via an electromagnetic wave propagation path. Then at time T_{stop} the detector is switched from Mode 1 to Mode 2, where deviation of the received signal strength statistics from that, estimated in Mode 1 is tested. If a deviation is found, then an event is detected within the VOI.

A surveillance system is thus, preferably represented by the quintuple {GE,TX,RX,f,DT}.

The propagation path from TX to RX comprises two parts: The Line-of-Sight (LOS) propagation paths, consisting of the contributions of the electromagnetic wave propagation from TX to RX, which contain no reflections or refractions of the waves and the Multipath (MP) propagation from TX to RX, where the electromagnetic waves have been reflected or refracted at least one time. It is noted that a design principle of TX, RX pairs, targeted for combining data communication and surveillance, might be based on a combination of minimizing the influence of MP for communication and maximizing the influence of MP for surveillance.

A complete surveillance system is a covering of Volume of Interest with a set of surveillance systems {GE,TX,RX,f,DT}, with known positions. They are in the following represented $\{GE_{i,j}, TX_j, RX_k, f_{j,k}, DT_{m,k}\}$ where:

$i=1,2,\ldots,G_j$ (the number of generators of transmitter j)

$j=1,2,\ldots,N$ (the number of transmitters)

$k=1,2,\ldots,R$ (the number of receivers)

$m=1,2,\ldots D_k$ (the number of detectors of receiver k).

It is noted that each transmitter might have several generators; that the carrier frequency might be dependent of the TX-RX pair, and thus spatial dependent; that each receiver might have several detectors.

The electromagnetic wave carrier frequency of TX is selected as a compromise between frequencies, which are sensitive to an event and frequencies which are technologically feasible. To obtain a shadow effect of a human being, also denoted a fade in the transmission from TX to RX, it is desirable with a carrier frequency not smaller than 1 GHz. Frequencies lower than 400 MHz mainly pass through the human body and frequencies higher than 3GHz are completely reflected by the human body.

At least two families of Surveillance Systems are contemplated:

- System function: Event detection. Such systems may preferably be embodied by use of: Custom designed hardware, WLAN, Bluetooth or the like.

- System function: Event detection, positioning, communication. Such system may *preferably be embodied by use of: Custom designed hardware,* WLAN, Bluetooth, any WLAN home network and might use anchoring elements for cone scanning.

An example of a preferred embodiment of a surveillance system according to the present invention utilises a Wireless Local Area Network (WLAN), exemplified by [IEEE 802.11, 1997]. In the following, the definitions related to WLAN are based on that standard.

The embodiment of the surveillance system utilises the following WLAN elements:

- Access Point (AP) [IEEE 802.11, 1997] p. 3, consisting of a transmitter AP-TX part and a receiver AP-TX part.
- Channel (CH) [IEEE 802.11, 1997] p. 3.
- RXVECTOR parameters [IEEE 802.11, 1997] p. 181, with Received Signal Strength Indicator (RSSI), which is an optional parameter that has a value of $0 - RSSI_{max}$. This parameter is a measure by the PHY sublayer, of the energy observed at the antenna used to receive the current PPDU. The RSSI is measured between the beginning of the start frame delimiter (SFD) and the end of the PLCP header error check (HEC). Thus the duration T_D of the energy measurement of RSSI is constant according to [IEEE 802.11, 1997] p. 183, Fig. 70, and is defind by the duration of SFD (16 bit) + PLW (12 bit) + PSF (4 bit) + HEC (16 bit) in total 48 bit. The duration between RSSI values are varying in time, and among others depending of the number of octets in the whitened PSDU.

A surveillance system is embodied as follows:

- GE≡Data sequence generator of PPDU, embodied in the computer associated with AP_1 –TX.
- TX≡AP_1 –TX, mounted in a fixed, known position in VOI.
- RX≡AP_2 –RX, mounted in a fixed, known position in VOI.
- DT≡Detection algorithm embodied in the computer associated with AP_2-RX.
- $S_1(t_n)$≡Value of RSSI at time t_n.

The DT-algorithm performs the following steps, in the GE_DT_1 function case:

Mode 1: Acquisition of $\{S_1(t_n)\}$ during the time window T_{start} to $T_{start}+T_1$, and switch at time $T_{start}+T_1$ into Mode 2.

Mode 2: Repeat

Acquisition of $\{s_s(t_n)\}$ during the time window $T+T_1$.

Perform a Kolmogorov-Smirnov test of identity of the empirical distribution function obtained during Mode 2 with the function obtained during the Mode 1, using a threshold TH.

If the empirical distributions are different

then an event is detected.

End Repeat.

If the WLAN performs both standard communication and surveillance, the compound system is denoted a Multimodal WLAN or a Multifunction WLAN.

A possible improvement is the application of a Cone-Scan performed between Surveillance Anchoring Access Points (SAAP), positioned close the floor in an indoor site and ordinary APs placed in the usual positions. The SAAPs might be used solely for communicating surveillance data sequences.

Examples of WLAN which can be embodied as a complete surveillance system:

- IEEE Std. 802.11b, which is a 11 Mbit/sec. WLAN in the 2.4 GHz band.
- IEEE Std. 802.11g, which is a 50 Mbit/sec. WLAN in the 2.4 GHz band.
- IEEE Std. 802.11a, which is 54 Mbit/sec. WLAN in the 5 GHz band.

The terminology used in connection with the present invention comprises:

AP:	Access Point of Wireless Local Area Network.
DS:	Data sequence.
DT:	Detector.
HEC:	Header error check.
PLCP:	Physical Layer Convergence Protocol, [IEEE 802.11, 1997] p. 8.
PLW:	Length of PSDU.
PPDU:	PLCP Protocol Data Unit.
PSF:	PLCP Signaling Field.
PSDU:	PLCP SDU.
RX:	Receiver.
SAAP:	Surveillance Anchoring Access Point of Wireless Local Area Network.
SDU:	Service Data Unit.
SFD:	Start frame delimiter.
TH:	Threshold in Event Detector.
TX:	Transmitter.
WLAN:	Wireless Local Area Network.
ε:	permittivity,
μ:	permeability
σ:	conductivity

The reference referenced herein (IEEE 802.11, 1997) is IEEE Std. 802.11-1997, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification

CLAIMS

1. A surveillance system comprising at least one transmitter adapted to transmit a signal in form of electromagnetic radiation and at least one receiver adapted to receive said signal in form of electromagnetic radiation, said system being further adapted to

- transmit, by use of one of the at least one transmitters, a first signal and a second signal, the second signal is succeeding the first signal,
- receive said first and second signals, by use of one of the at least one receivers, and
- detect a physical change, if present, in the vicinity of the transmitter transmitting and the receiver receiving and occurring between initiating of transmittal of the first signal and termination of receiving of the second signal by detecting a change, provided by said physical change, in signal strength between the first and the second signal.

2. A surveillance system according to claim 1, wherein the first signal is transmitted during a pre-selected first time window and wherein the second signal is transmitted during a pre-selected second time window, said first and second time windows have preferably equal durations.

3. A surveillance system according to claim 1 or 2, wherein each of the signals transmitted is a constant signal, such as a carrier wave or a carrier wave like.

4. A surveillance system according to claim 1 or 2, wherein said system being adapted to transmit the first and the second signals as a first and a second set of packets of electromagnetic radiation respectively, being adapted to receive the first and the second set of packages and compare the statistics on the signal strength of each package to identify differences between the energy contents of the first and the second set of packages

5. A surveillance system according to any of the preceding claims, wherein the transmitter(s) and the receiver(s) are components of a wireless network used for data transmission and/or positioning.

6. A surveillance system according to claim 5, wherein wireless network is a wireless local area network used for data transmission and/or positioning.

7. A surveillance system according to any of the preceding claims, wherein the a transmitter and a receiver is combined into a transmitter.

8. A surveillance method, said method is utilising at least one transmitter adapted to transmit a signal in form of electromagnetic radiation and at least one receiver adapted to receive said signal in form of electromagnetic radiation, said method comprising the steps of

- transmitting, by one of the at least one transmitters, a first signal and a second signal, the second signal is succeeding the first signal,
- receiving said first and second signals, by one of the at least one receivers, and
- detecting a physical change, if present, in the vicinity of the transmitter transmitting and the receiver receiving and occurring between initiating of transmittal of the first signal and termination of transmittal of the second signal by detecting a change, provided by said physical change, in signal strength between the first and the second signal.

9. A method according to claim 8, wherein the first signal is transmitted during a pre-selected first time window and wherein the second signal is transmitted during a pre-selected second time window, said first and second time windows have preferably equal durations.

10. A surveillance system according to claim 8 or 9, wherein each of the signals transmitted is a constant signal, such as a carrier wave or a carrier wave like.

11. A method according to claim 8 or 9, wherein the first and the second signals are transmitted as a first and a second set of packets of electromagnetic radiation respectively, and wherein the method comprising the steps of receiving the first and the second set of packages and comparing the statistics on the signal strength of each package to identify differences between the energy contents of the first and the second set of packages

12. A method according to any of the claims 7-11, wherein the first and the second signals are transmitted and received in a wireless network used for data transmission and/or positioning.

13. A method according to claim 12, wherein the wireless network is a wireless local area network used for data transmission and/or positioning.

14. A surveillance system according to any of the claims 8-13, wherein the first and the second signals are transmitted and received by receivers.

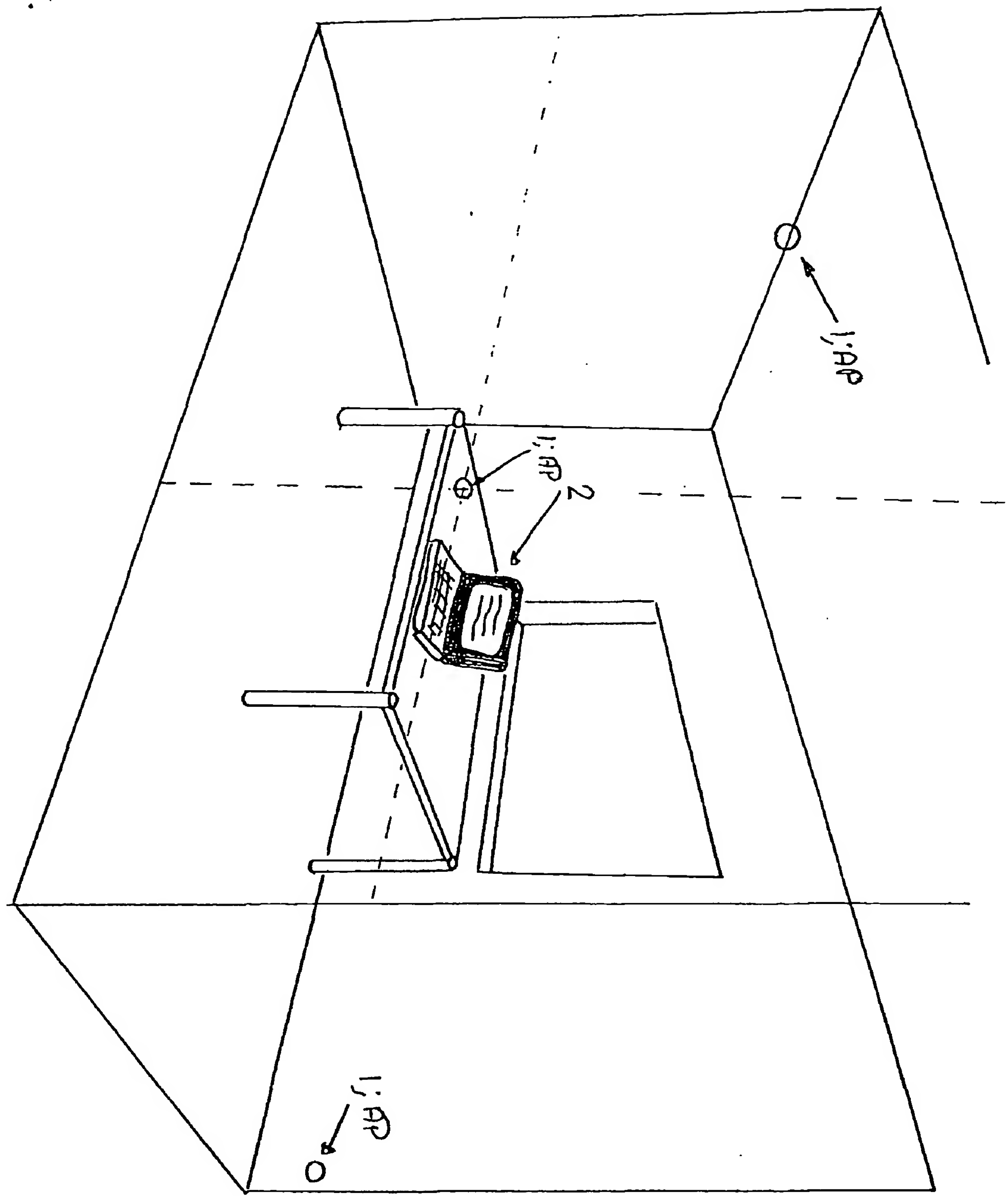

Fig. 1